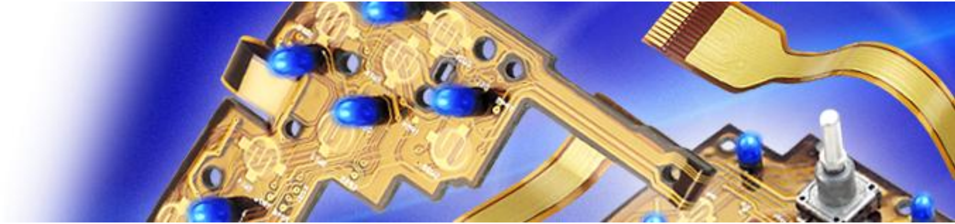


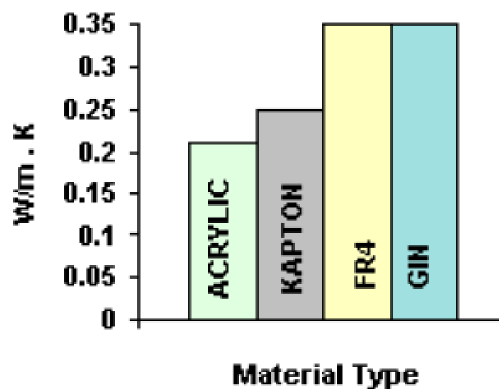
Thermal Management

New technologies for emerging markets:
Flexible circuits master the art of thermal management

In all areas of technology, advances are being driven by the demands of the end user. In our sector, electronic packaging, the call is for smaller, faster and more cost effective solutions. Our answer is to concentrate our R&D efforts in satisfying the needs for the next generation of electronic systems.One area of concentration and possibly the greatest challenge in reaching the next plateau in electronic packaging is thermal management.

In recent times, the problems of thermal management have been compounding at an exponential rate due to the combination of denser packaging, resulting in reduced opportunity for ambient air cooling and faster processing speeds, necessitating increased thermal dissipation. Each of these factors considered individually pose their own mechanical and electrical problems but their combination requires unique solutions.

Figure 1: Thermal Conductivity



Many different methods have been utilized to improve component heat dissipation both on conventional hardboards and rigid flex type constructions. Such features as heat rails, aluminum hats, fins (conductive transfer) and even refrigerated housings (radiation transfer) were partial solutions, but they were all solutions that add weight, cost and size: something unacceptable to the end user. Packaging engineers were focusing on design features to offset the thermal mass of the overall board. These approaches considered the correct problem (thermal mass) but not from an utopian objective.

The thermal conductivity characteristics for traditional circuit board materials (rigid and flexible) are very similar.

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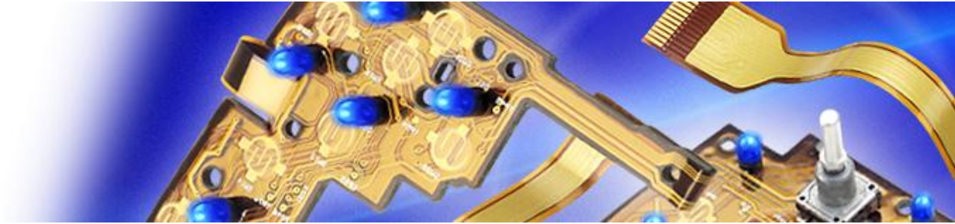
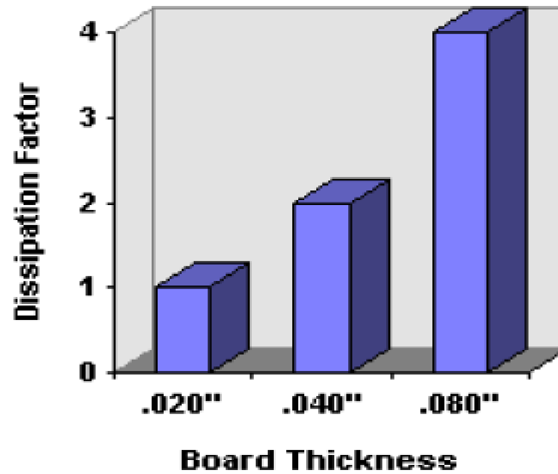


Figure 2: Heat Distribution



Further investigation shows us that board volume plays a much larger role than material selection in total thermal management .

The relationship is simple; mass = volume x density, assuming the material densities are relatively equivalent, board volume (contact area x thickness) becomes the critical variable. Generally speaking the PCB footprint is dictated by the circuit design, therefore the first consideration is how much surface area is exposed to the chosen heat conductor. In glass reinforced constructions heat is dissipated mainly through the glass bundles. This reduces the effective contact area considerably. A flexible substrate is a homogenous film which dissipates heat evenly across it's entire surface, this means the effective contact area is optimized.

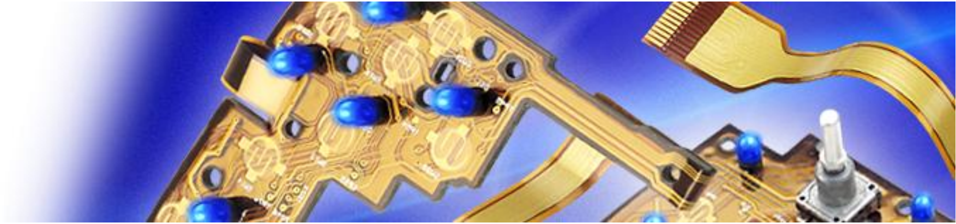
The second variable is board thickness. Conventional PCB technology is capable of reducing thickness considerably but not to the extremes possible with flexible substrates.

The goal is for smaller and faster interconnect solutions but conventional Printed Circuit Board's only partially address this concept. An ultra thin adhesiveless flexible circuit offers more by offering the packaging designer the ability to improve thermal characteristics, primarily by reducing circuit thickness but further by attaching the circuit directly to a metallic baseplate results in thermal dissipation characteristics unheard of with traditional approaches.

Consider some typical values of thermal conductivity for common metals (table. 1).

Table. 1 - Thermal Conductivity Values for Common Metals

Metal Type	Thermal Conductivity (W/m . K)
Stainless Steel	16-20
Cast Iron	50-60
Nickel	57-95
Aluminum	117-127



We see that by utilizing ultra-thin circuit constructions attached directly to a highly temperature conductive metallic baseplate results in the most superior thermally managed package available today. In this case heat is being conducted from the circuit almost exclusively by direct heat transfer (conduction). Add to this the ultimate space saving tool - 3 dimensional packaging, and flexible circuitry offers complete freedom of design.

Concepts such as these are already being utilized in ‘under the hood’ automotive applications and other heat intensive environments. Fabrication of a flexible circuit board attached to a base plate (giving superior thermal characteristics) provides the ideal handling medium to facilitate component assembly. Finally the baseplate folds up to become an integral part of the system housing.

Industry efforts continue to drive towards more homogenous constructions utilizing enhanced materials for circuit to baseplate attachment. The electronics industry will benefit from the release of products that incorporate these ideals later this year.

In summary the future of flexible circuits in thermally managed applications is extremely bright. New material innovations with highly controlled thermal mass characteristics are being rapidly developed and these coupled with ultra thin flexible substrates will emerge to meet the future needs of the electronics marketplace.